CTD Information GUIDE

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Preventing Cumulative Trauma Disorders in the Workplace

July 1992

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The U.S. Army Safety Center/
U.S. Army Environmental Hygiene Agency CTD Task Force

CTD Information Guide

Purpose

To provide Army occupational safety and health (OSH) professionals with a primer that explains the basic principles of ergonomic-hazard recognition for common cumulative trauma disorders (CTDs) and suggest solutions for improvement.

Description

Defines common CTDs, in particular carpal tunnel syndrome. Discusses health problems (and their solutions) posed by video display terminals, handtools, and powered handtools. Addresses the elements of an effective ergonomics program: worksite analysis, hazard prevention and control, medical management, and training and education. Includes a bibliography, ergonomics checklists, and a source list of ergonomic handtools and devices manufacturers.

Audience

This technical publication is aimed at occupational safety and health professionals. A second version of more general application will be made available for supervisors.

Enhancement

This guide offers OSH professionals an introduction to CTDs. However, to be fully effective in eliminating or controlling these hazards, additional training is required. Both the U.S. Army Environmental Hygiene Agency and the U.S. Army Safety Center conduct such training. For additional information, contact—

Commander
U.S. Army Environmental Hygiene Agency
ATTN: HSHB-MI-W
Aberdeen Proving Ground, MD 21010-5422
DSN 584-3928, commercial 410-671-3928

Commander
U.S. Army Safety Center
ATTN: CSSC-PS
Fort Rucker, AL 36362-5363
DSN 558-4479, commercial 205-255-4479

Contents

Introduction

What are cumulative trauma disorders (CTDs)?

The Occupational Safety and Health Administration (OSHA) defines CTDs as "health disorders arising from repeated biomechanical stress due to ergonomic hazards." Simply put, the pain, tingling, numbness, and/or weakness associated with CTDs are the result of irritation (inflammation) and swelling of nerves, tendons, ligaments, and linings of joint spaces from repeated overuse of the affected structures.

These health disorders are more specifically defined as a class of neuromuscular disorders involving damage to muscles, tendons, tendon sheaths, and nerves. Common CTDs include—

- **Carpal tunnel syndrome.** Results from pressure exerted on the median nerve by swelling of any of the tendon sheaths surrounding the nerve or direct pressure on the nerve from hard, sharp edges of work surfaces or tools.
- **Low back pain.** Currently felt to be a CTD where repeated bending, lifting, and twisting of the lower back results in cumulative microtrauma. An aggravating event (e.g., slip, trip, fall, awkward lift) often causes an acute episode to occur.
- **Tendonitis.** An irritation (inflammation) of a tendon resulting from repeated tensing of that muscle/tendon group.
- **Lateral epicondylitis (tennis elbow).** An irritation (inflammation) of the tendons attached on the outside of the elbow from activities that have jerky throwing motions or impact (e.g., hammering).
- **Medial epicondylitis (golfer's elbow).** An irritation (inflammation) of the tendon attachments on the inside of the elbow resulting from activities that require repeated or forceful rotation of the forearm and bending of the wrist at the same time.
- **Tenosynovitis.** An irritation (inflammation) of the tendon and the lining of the smooth sheath surrounding the tendon resulting from repeated movement of the tendon in the sheath.
- **Synovitis.** An irritation (inflammation) of the inner lining of the membrane surrounding a joint.
- **Stenosing tenosynovitis of the finger.** Results from a tendon surface becoming irritated and rough. If the tendon sheath also becomes inflamed and presses on the tendon, a progressive constriction of the tendon can occur, resulting in a loss of free movement in that joint area. For example, "trigger finger" is a condition where the tendon sheath of the affected finger is sufficiently swollen so that the tendon becomes locked in the sheath, and attempts to move the finger will result in a jerking or snapping motion in that finger.
- **DeQuervain's Disease.** A stenosing tenosynovitis affecting the tendons on the side of the wrist and base of the thumb. Constriction of these tendons tends to pull the thumb back away from the hand.

Other terms for CTDs are repetitive motion injury, occupational overuse syndrome, and repetitive strain injury.

In recent years, the number of CTDs due to ergonomic hazards has substantially increased. In fact, CTDs account for nearly half of the occupational illnesses reported in the annual Bureau of Labor Statistics survey and an increasingly large percentage of annual workers compensation claims. CTDs are a significant problem for the Army as the costs associated with workers compensation continue to escalate.

CTDs are health disorders arising from repeated biomechanical stress due to ergonomic hazards.

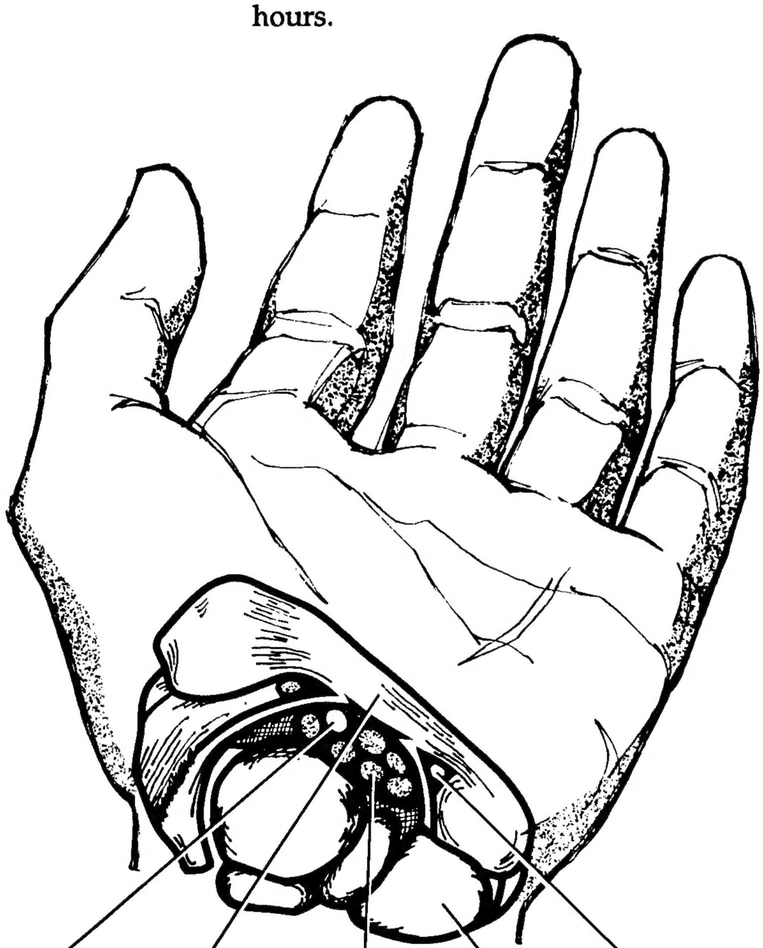
Carpal tunnel syndrome

Carpal tunnel syndrome (CTS) is caused by occupational factors such as—

■ Repetitive motions.

■ Forced and awkward posture.

■ Exposure to vibrations for long hours.



To understand the effects these factors have on the fingers, wrist, and forearm, it is helpful to understand the physiology of the carpal tunnel.

Physiology of the carpal tunnel

The wrist and fingers are flexed by muscles located in the forearm. The muscles are connected to the wrist and fingers by tendons that run through the wrist at the carpal tunnel. These tendons enter the wrist through a U-shaped cluster of eight bones, the carpal bones, which form the "back" and "sides" of the wrist. Across the "top" of the wrist is a tough, strong ligament that forms the arch of the carpal bones or the roof of the tunnel.

The tendons, which allow finger and wrist flexing, are surrounded by a sheath that secretes a lubricating fluid much more slippery than motor oil. This fluid allows almost friction-free movement of the tendons. Sandwiched in this group of tendons is the median nerve, which conducts sensation from the hand to the central nervous system. This nerve, being the softest part of the tunnel, is susceptible to compression.

Carpal tunnel syndrome occurs when the median nerve is compressed within the carpal tunnel area. The nerve can be trapped when the tendons become inflamed or swell when the sheath becomes irritated and inflamed. In either case, the structures within the carpal tunnel expand, and the nerve,

Occupational factors associated with carpal tunnel syndrome

Carpal tunnel syndrome is a disorder of the hand characterized by pain, weakness, and numbness in the fingers, caused by nerve compression in the wrist.

Occupational factors associated with carpal tunnel syndrome include—

• Hands held in fixed positions over prolonged periods.

• Repeated wrist and finger flexion.

• Light, highly repetitive wrist and finger movements such as typing or data entry.

• Repeated flexion or hyperextension (wrist and hand bent back) of the wrist.

• Prolonged strenuous use of the hands.

• Repeated pinching or grasping.

• Vibration, particularly that associated with power tools.

• Bending the wrist toward the little finger.

• Acceleration and velocity of dynamic motions.

with nowhere to go, gets squeezed within the limited confines of the carpal tunnel.

Symptoms of carpal tunnel syndrome

When the median nerve is compressed, the following typical CTS symptoms appear:

- Burning pain.
- Numbness.
- Tingling in the thumb and the first two or three fingers.

These symptoms may radiate to the forearm. Sufferers frequently feel these symptoms at night, and many find performing simple tasks, such as tying their shoelaces, difficult because of weakness or numbness.

Carpal tunnel syndrome prevention

Focus prevention on—

- Reducing exposure to suspected causes.
- Conditioning or training the muscles to have a better tolerance for repeated motions.

Control these risk factors by controlling—

- Repetitiveness.
- Forcefulness.
- Posture.
- Vibration.
- Mechanical stress.

Early recognition of the signs and symptoms of CTS and recognition of occupational risk factors should reduce the number and severity of cases of CTS.

Video display terminals

Computers, and their accompanying video display terminals (VDTs), have pervaded the workplace, invading job sites and occupations where they have not been used before. Over 30 million VDTs are in use throughout the United States, and the number is growing rapidly.

Growing as rapidly as the numbers of VDTs are the health problems associated with prolonged VDT use. Those workers who use VDTs irregularly and discontinuously throughout the workday are generally not affected by VDT use. However, those workers who use VDTs continuously, from 6 to 8 hours during the workday, can experience VDT-related ailments and discomforts.

Health problems associated with VDT use

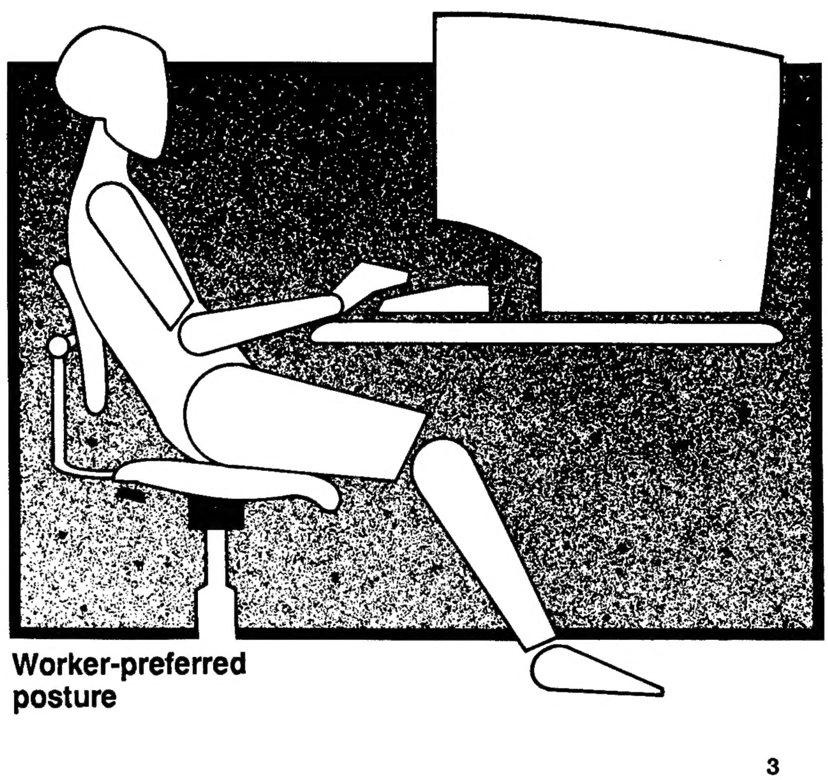
The health problem reported most often with prolonged VDT use is increased fatigue or the earlier onset of fatigue. Fatigue may be muscular, mental or emotional, visual, or a combination.

Muscular fatigue is characterized by—

- Pain.
- Stiffness.
- Physical discomfort.
- Cumulative trauma disorders.

Mental or emotional fatigue is characterized by—

- Weariness.
- Loss of concentration.
- Irritability.



Worker-preferred posture

■ Dizziness.

Visual fatigue is characterized by—

■ Eye discomfort due to frequently changing focus.

■ Eye irritation.

■ Headache.

■ Abnormal afterimage.

■ Disturbed acuity.

Whether VDT workers are experiencing one or a combination of these problems, the results are the same—a loss in proficiency and productivity.

Solutions to VDT health problems

More often than not, VDTs are placed in worksites on existing work surfaces that are neither adjustable nor comfortable for the majority of the workers. The person is fitted to the task, rather than the task to the person. Physical discomfort in the neck, shoulders, arms, or hands may occur if—

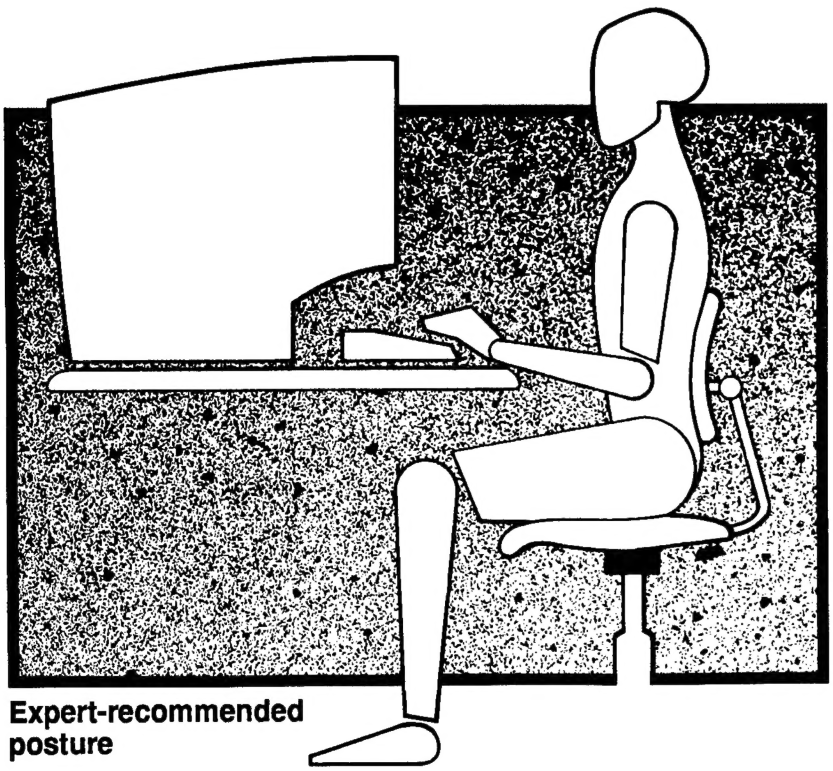
■ The keyboard level is either too low or too high.

■ Forearms and wrists cannot rest on an adequate support.

■ Workers have a marked head inclination.

■ Workers adopt a slanting position of the thighs under the table due to insufficient space for the legs.

■ Workers disclose a marked ulnar deviation of the hands (bending of the wrist towards the little finger) when operating the keyboard.



Expert-recommended posture

Workstation "adjustability" is the key to minimizing or eliminating the amount of discomfort caused by prolonged VDT use. Design VDT workstations so that—

■ The furniture is as flexible as possible, adjustable to the following dimensions—

□ Keyboard height from floor to home row: 27.5 to 33.5 inches (70 - 85 cm)

□ Screen center above floor: 35.5 to 45.3 inches (90 - 115 cm)

□ Screen inclination to horizontal: 88° to 105°

□ Keyboard home row to table edge: 3.9 to 10.2 inches (10 - 26 cm)

□ Screen distance to table edge: 19.7 to 29.5 inches (50 - 75 cm)

□ Screen distance from worker to display and document: 2 feet (61 cm) for the typical 1/8 inch (0.7 cm) character height

■ The controls for adjusting the dimensions are easy to handle, particularly at workstations with rotating shift work.

■ At knee level, the distance between the front table edge and the back wall is not less than 23.6 inches (60 cm) and, at foot level, at least 31.5 inches (80 cm).

The benefits of a well-designed workstation will be partially or totally offset if coupled with a poorly designed and uncomfortable chair. Ideally, VDT workstation chairs should be tiltable, designed for a forward and reclining posture, and have—

■ A backrest height of 18.9 (48 cm) to 20.5 inches (52 cm) vertically above the seat surface.

■ A backrest with a well-formed lumbar (lower back) pad that offers good support to the lumbar spine between the third vertebra and the sacrum. The lumbar support should have a width of 12 inches (30.5 cm), height of 6 to 9 inches (15.3 to 22.9 cm), and placement at 4 to 8 inches (10.2 to

20.3 cm) above the lowest part of the seat. However, the lumbar support should allow for the assumption of different postures.

- A seat surface measuring 15.7 to 17.7 inches (40 - 45 cm) across and 15.0 to 16.5 inches (38.1 to 42 cm) from front to back. A slight hollow in the seat with the front edge turned upwards about 4° to 5° will prevent the buttocks from sliding forward. A "waterfall" contour for the front of the seat is recommended to prevent compression of the thigh.
- A footrest to keep feet from hanging from the edge of the chair, which causes the weight of the thigh and lower leg to exert pressure behind the knee, pressing on blood vessels and nerves.
- Adjustable, removable, and padded armrests to rest forearms and elbows. The armrests should be 9 inches (22.9 cm) above the lowest part of the seat with a range of 7 to 11 inches (17.8 to 28 cm). They should extend forward 6 to 7 inches (15.3 to 17.8 cm), have 19 inches between the two armrests, and be a minimum of 2 inches (5 cm) wide.
- The basic requirements of any modern office chair:
  - Adjustable height
  - Swivel
  - Rounded, waterfall-type front edge of the seat surface
  - Castors or glides
  - Five-arm base
  - User-friendly controls

Although alternatives to the standard QWERTY keyboard are not commonly available, certain designs can reduce the risk of CTDs. The keyboard should be separate from the display and adjustable in the horizontal plane. Ideally the keyboard should be as thin as possible to allow the forearms to operate in the horizontal plane. Additionally, the keyboard should provide for wrist/forearm support.

Need for Special VDT Workstations
(Bell Canada Recommendations)

Time spent at workstation	Special workstation
25 percent or less	Not normally provided
25 to 49 percent	Considered
50 percent or more	Normally provided

Handtools

Handtools are designed to extend and reinforce the range, strength, and effectiveness of a person's limbs. However, problems with the design and use of handtools account for 5 to 10 percent of compensable injuries in the workplace. The simple handtools most often cited are knives, wrenches, and hammers.

Although traumatic injuries such as cuts and smashed fingers are most commonly associated with these tools, they are also responsible for CTDs. These disorders are rarely reported, but may lead to reduced productivity, degradation in work quality, and increased absenteeism.

To understand how handtools can cause CTDs, it is necessary to understand the basic anatomy and functioning of the hand.

Anatomy and functioning of the hand

The human hand is a complex structure consisting of bones, nerves, blood vessels, ligaments, and tendons. Finger flexion is caused by forearm muscles that are connected to the fingers by means of tendons that run through a channel in the wrist called the carpal tunnel. Also running through this tunnel is the median nerve and radial artery.

The bones of the wrist connect to the two long bones of the forearm—the radius, connecting to the thumb side of the wrist, and the ulna, connecting to the little finger side of the wrist. This configuration permits wrist movement in essentially two planes, each approximately 90 degrees to the other—

- The first plane permits *palmar flexion,*

bending of the hand toward the wrist; the opposite is called *dorisflexion,* bending of the hand toward the back of the wrist.

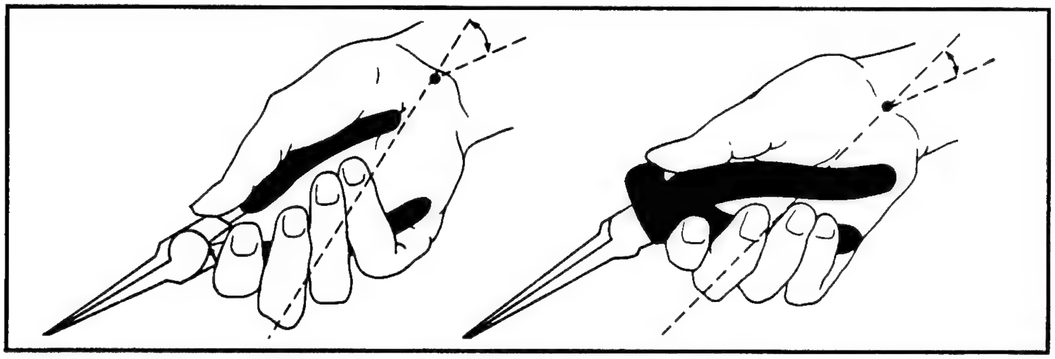


Figure 1. Redesigned standard pliers to eliminate ulnar deviation.

■ The second plane of motion of the wrist is bending the wrist toward the *ulnar* or *radial deviation.*

Health problems associated with handtool use

Though handtools have become increasingly sophisticated, improper design is responsible for the more serious effects of CTDs—

■ **Tenosynovitis (inflammation of tendon sheath).** Typically caused by the clockwise motion of one hand complementing the counterclockwise motion of the other; examples include—

□ Inserting screws in holes

□ Operating throttle controls on motorcycle handlebars

□ Looping wire using pliers

■ **Stenosing-tenosynovitis-crepitans ("trigger finger").** Caused by the hand exerting grip forces on a rigid tool handle such as pliers, transmitting the forces to the underlying soft tissue, and inflaming the tendon or tendon sheath.

■ **Raynaud's phenomenon (white finger or vibration syndrome).** Caused by a reflexive constriction of the small arteries causing the fingers to become white (pale) and feel cold, numb, and tingly.

■ **Epicondylitis.** Caused by repetitive movements of the forearm and wrist, leading to inflammation of the tendons that attach the finger extensor muscles to the elbow. Injuries are frequently caused when these tendons are strained or overused such as when using wire brushes overhead.

In addition to tendon disorders, poorly designed handtool handles can affect nerves in the fingers. For example, the digital nerves, which run along the sides of the fingers, are compressed when using scissors and can result in numbness and tingling in the ends of fingers.

Static muscle loading—the fatigue and muscle soreness in the shoulder, arm, and hand caused by elevating or holding a tool in one position— can also be attributed to handtool use.

Solutions to handtool health problems

Ideally, handtools should be designed—

■ So that, during tool use, the wrist is maintained in a neutral or relaxed position such as when the arm hangs relaxed at one's side.

■ With handles that—

□ Distribute the hand-force concentration over a greater surface area.

□ Are comfortable to hold.

□ Reduce compressive forces on the hand surface.

□ Are well-rounded.

□ Are as large as will fit the hand comfortably.

□ Are covered with a compliant material such as plastic or rubber.

□ Are long enough to distribute forces over the large fleshy areas at the base of the thumb and little finger.

To reduce the likelihood of CTDs caused by handtools *currently* in use, retrofit the tool handles with compliant materials such as rubber or blow-molded plastics. However, do not use thick coatings because they may cause the user to grip handles more forcefully to operate the tool.

The use of ergonomically designed handtools significantly reduces the risk of CTDs. Moreover, tools that fit in the hand comfortably will ultimately result in increased productivity.

Ergonomic handtool and device manufacturers

There are several manufacturers of ergonomic handtools and devices, with more appearing each year. In addition, some companies can retrofit currently used tools with compliant materials such as dipped or blow-molded plastics. The following list is for information purposes only and is not intended as an endorsement by the Army Safety Center, the Army Environmental Hygiene Agency or Department of Army.

Ames
P.O. Box 1774
Parkersburg, WV 26101
(*Handtools*)

AMP, Inc.
Advanced Mfg. Tech. Div.
3901 Fulling Mill Road
Middletown, PA 17057
(*Handtools and automated systems for electrochemical connections*)

Atlas Copco Industrial Tools, Inc.
24404 Indoplex Circle
Farmington Hills, MI 48018
313-478-5330
(*Handtools*)

BAHCO Tools, Inc.
c/o GETC
570 Lexington Avenue
New York, NY 10022
212-750-3823
(*Handtools*)

Bettcher Industries
P.O. Box 336
Vermillion, OH 44089
800-321-8763
(*Power knives*)

Bodyguard Seating Systems
A Division of Advanced Dental Concepts, Inc.
7 North Pinckney St., Ste. 305
Madison, WI 53703
608-256-0344

Cooper Industries
P.O. Box 728
Apex, NC 27502
919-362-7510
(*Scissors*)

Stanley Air Tools
700 Beta Drive
Cleveland, OH 44143
216-461-5500
(*Power handtools*)

Dresser Industries, Inc.
Industrial Tool Div.
7007 Pienmont
Houston, TX 77040
713-462-4521
(*Power handtools/accessories*)

Dynamics Operational, Inc.
600 Fondulac Drive
East Peoria, IL 61611
309-699-6046
(*Handles*)

Fiskars
P.O. Box 1727
Wausau, WI 54401
(*Handtools*)

ITD Automation
1765 Thunderbird
Troy, MI 48084
313-244-9250
(*Articulating arms*)

Klein Tools, Inc.
7200 McCormick Blvd.
Chicago, IL 60645
312-677-9500
(*Handtools*)

SCANDEX, Inc.
87 Crescent Road
Needham, MA 02194
617-449-1550
(*Handtools*)

Seymour Smith & Son, Inc.
Snap-Cut
Oakville, CT 06779
203-274-2558
(*Plant/flower shear*)

Sorbothane, Inc.
P.O. Box 178
Kent, OH 44240
800-321-0171,
216-678-9444
(*Vibration dampening material*)

Steere Enterprises
285 Commerce Street
Tallmadge, OH 44278
216-633-4926
(*Custom dip/blow molding, plastics*)

Stirex Innovation
c/o Intercodev, Inc.
4 Royal Oak Court
Holbrook, NY 11741
516-472-6834
(*Handtools, scissors, aids for disabled*)

Sullair Corp.
3700 E. Michigan Blvd.
Michigan City, IN 46360-9990
800-348-2722
(*Air hammers*)

Sunnex Equipment, AB
Box 242
686 00 Sunne
Sweden
(*Handgrips, powertools*)

Powered handtools

Powered handtools allow heavier work to be performed with greater speed and efficiency. However, if poorly designed or improperly used, these tools have the potential to cause a number of CTDs.

Factors affecting the health of powered handtool users

Whether the tools are powered by electricity, gas, compressed air, or explosive charges, a number of factors affect the performance and health of tool users:

■ The static loading of arm and shoulder muscles from holding the tool in position. Static loading, particularly of the forearm, will cause fatigue and reduced productivity with possible muscle soreness. A tool that weighs 10 to 15 pounds (4.5 to 6.8 kg) cannot be held in a horizontal position for more than a few minutes without extreme forearm discomfort.

■ Awkward postures, such as those where the wrist is hyperflexed or extended, stretch the underlying tendons and blood vessels over the rigid carpal bones or wrist ligament. Given that awkward postures coupled with static loading increase the risk of CTDs, power tool handles and grips should be designed to allow the wrist and forearm to remain in a neutral position, neither hyperflexed or extended nor bent to the left or right. This may indicate that a pistol-grip tool may not be suitable for all tasks.

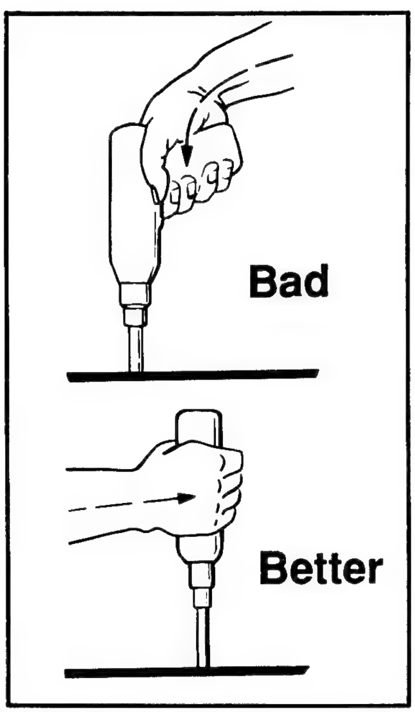


Figure 1.

■ Pressure exerted on the palm and fingers may be greater for power tools than for handtools for two reasons: first, power tools are usually heavier than handtools, requiring a more forceful grip to maintain control of the tool; secondly, power tools tend to vibrate during operation, causing the user to grip more forcefully to maintain control of the tool.

■ Vibration and noise associated with the power tools. Vibrating tools such as chain saws, pneumatic drills, grinding tools, and chipping hammers can cause vascular spasm—constriction of blood vessels in the fingers, which then appear white or pale. Vascular constriction may lead to numbness and swelling of hand tissue, with loss of grip strength. Vibration-induced white finger, also called "white finger," "dead finger," "occupational Raynaud's," and "vibration syndrome," afflicts its victims with tingling, numbness, or pain that can be brought on or intensified by exposure to cold.

Tools that intensify any or all of these factors significantly increase the risk of CTDs.

Solutions to powered handtool health problems

Static muscle loading. A tool such as a power grinder or sander cannot be held in one position for more than a few minutes without extreme forearm discomfort, fatigue, possible muscle soreness, and reduced productivity.

■ Frequently used or continuously held tools should be as light as possible, preferably under two pounds.

■ Heavier tools should be suspended overhead using retractor linkage.

■ The tool's center of gravity should be aligned with the center of the grasping hand to allow the user to align the tool with minimal effort.

Awkward postures. Tools that force the user to assume awkward hand, wrist, and arm postures cause a mismatch between the job and the tool, increasing the risk of CTDs. To avoid CTDs, resolve awkward postures by—

■ Rotating the workpiece 90° to the horizontal, allowing the operator to maintain a straight wrist.

■ Substituting a tool with an in-line handle for a tool with a pistol grip, allowing the operator to maintain the wrist in a neutral position. See figure 1.

■ Placing the tool on an adjustable jig, allowing the tool to be positioned so that the user can maintain the wrist in a near-neutral position. See figure 2.

Pressure exerted on the palm and fingers. As with manual tools, the shape, location, and size of the handle should minimize the compressive pressure on the inner surfaces of the palm and fingers.

■ Hand grips should be cylindrical in shape with no sharp edges.

■ Handles should be at least 4.0 inches (100 mm) long, and those used with gloves should be 0.4 inches (10 mm) longer.

Power-tool triggers are normally located in the handle and operated by the index finger. If poorly designed, a condition known as "trigger finger" can result. This occurs when a tool is so large that the last segment of the index finger must be used to depress the trigger, while the middle segment remains straight. Power handtools should be designed so that—

■ Frequent use of the index finger is not necessary.

■ Triggering mechanisms are large enough for activation by two or three fingers.

Vibration and noise. The vibration of powered handtools such as chain saws, pneumatic drills, grinding tools, and chipping hammers can cause vascular spasm—the constriction of blood vessels in the fingers, which then appear white or pale (known as vibration-induced white finger or VWF). Vascular constriction may lead to numbness and swelling of hand tissue, with loss of grip strength.

In addition, tasks that require repeated flexion and extension of the wrist, such as sanding, can stress the wrist tendons, possibly leading to carpal tunnel syndrome.

Powered handtools vibrating at frequencies between 3 and 125 hertz, with a corresponding amplitude of greater than 100 micrometers, are most likely to cause VWF and other CTDs.

In 1989, the National Institute for Occupational Safety and Health (NIOSH) published a recommended standard for occupational exposure to hand-arm vibration. The following engineering controls were recommended:

■ Reduce the level of vibrating energy produced by the vibrating tool.

■ Effectively use power and tool weight to minimize vibration.

■ Require tool manufacturers to furnish vibration and frequency data on their tools.

The following work-practice controls were recommended:

■ Reduce the number of hours or days vibrating tools are used.

■ Arrange tasks to alternate use of vibrating and nonvibrating tools.

■ Schedule tool maintenance so tools remain sharp, lubricated, and properly tuned.

■ Select tools that perform satisfactorily with the least vibration.

■ Incorporate into the workplace design ergonomic principles to lessen vibration stresses.

■ Reduce handle grip force.

■ Use gloves with vibration-damping materials in the palms and fingers.

■ Use tools with vibration-damping handles.

■ Use antivibration isolators or damping techniques on tools.

■ Use antivibration equipment, clothing, and handgear that are ergonomically appropriate.

Figure 2.

Establishing an ergonomics program

Ergonomics—also called *human engineering*—adapts the job and the workplace to the worker by designing tasks and tools that meet the worker's capabilities and requirements.

The goal of an ergonomics program is to eliminate or reduce worker exposure to conditions that—

- Do not meet worker capabilities.
- Do not consider worker limitations.
- Lead to CTDs and related injuries and illnesses.

According to OSHA, the implementation of an effective ergonomics program requires—

- Commitment by top management.
- A written program.
- Worker involvement.
- Regular program review and evaluation.

The major program elements to effectively deal with ergonomic hazards are—

- Worksite analysis.
- Hazard prevention and control.
- Medical management.
- Training and education.

Commitment by top management

An effective ergonomics program should have a team approach, led by top management.

- Managers should show *personal* concern for worker safety and make the elimination of ergonomic hazards a priority.
- Managers should consider safety and health to be as important as production. Safety and health protection should be built into daily production activities.
- All managers, supervisors, and workers should be—
    - Informed of their responsibilities for various aspects of the program.
    - Given the authority and resources to meet their responsibilities.
    - Held accountable for carrying out their responsibilities.

Written program

Effective implementation requires a written program for job safety, health, and ergonomics that is—

- Endorsed and advocated by top management.
- Suitable for the size and complexity of the workplace.
- Communicated to and understood by *all* personnel.

The written program should outline goals and objectives and include an implementation schedule for worksite analysis, hazard prevention and control, medical management, and training and education.

Worker involvement

Workers should be encouraged to be involved in the ergonomics program and in decisions that affect their safety and health.

- *A complaint or suggestion procedure* allows workers to bring their concerns to management without fear of reprisal.
- *A reporting procedure* encourages workers to identify the signs and symptoms of CTDs so they may be evaluated and treated.
- *Safety and health committees* receive and analyze information on ergonomic problem areas and make recommendations for corrective action.
- *Ergonomic teams or monitors* identify and analyze jobs for ergonomic stress and recommend solutions.

Regular program review and evaluation

Managers, supervisors, and workers should review the ergonomics program regularly to evaluate its success in meeting stated goals and objectives.

Management's review should be in the form of a written progress report, and should be shared with all workers. Any new or revised goals should also be shared with the workers. Any deficiencies should be identified and corrective action taken.

Procedures and mechanisms to evaluate the program and monitor its progress include—

- Analysis of trends in injury/illness rates.
- Employee surveys.
- Before and after surveys and evaluations of job/worksite changes.
- Review of results of workplace evaluations.
- Up-to-date records or logs of attempted or implemented job improvements.

Worksite analysis

To determine those tasks that place workers at risk of developing CTDs, an individual trained to recognize ergonomic risk factors identifies—

- Existing hazards and conditions.
- Operations that create hazards.
- Areas where hazards may develop.

To aid in the identification of tasks or jobs associated with CTD-type injuries—

- Review CA-1 and CA-2 claims.
- Review the OSHA 200 log.
- Examine occupational health medical records for back, shoulder, arm, and hand illnesses or injuries.
- Interview the personnel office, supervisors, and employees.
- Survey CPO records for jobs with high turnovers or excessive absenteeism.

Hazard prevention and control

Engineering controls. This is the primary control method and should include designing workstations, work methods, and tools to prevent or control hazards.

- Workstations should be easily adjustable and designed for specific tasks.
- Work methods should reduce or avoid awkward, extreme, or static postures, repetitive motion, and excessive force.
- Tools should fit properly and not force awkward postures.

Work practice controls. These controls include—

- Proper work techniques.
- Providing new employees with a conditioning period.
- Monitoring all levels of operations.
- Modifying controls when the dynamics of the workplace change.

To be successful, an ergonomics program must work within the existing occupational safety and health program

Personal protective equipment (PPE). The key to selecting PPE is that its use should not increase ergonomic stressors—incorrect or ill-fitting PPE may actually make stressors worse. Appropriate PPE should—

- Be provided in a variety of sizes.
- Accommodate the physical requirements of workers on the job.
- Not contribute to extreme postures and excessive forces.

Administrative controls. These controls include reducing the duration, frequency, and severity of exposure to ergonomic stressors. Administrative controls can—

- Reduce the number of repetitions per employee by decreasing production rates or limiting overtime.
- Provide rest periods to relieve fatigued muscle-tendon groups.
- Increase cycle time.
- Increase number of employees assigned to a task.
- Rotate to a nonstress task.
- Increase type and variety of task.
- Maintain equipment.
- Maintain effective housekeeping to eliminate slip and trip conditions.

Medical management

Medical management requires that health care providers be knowledgeable in preventing and treating CTDs. A medical management program for CTDs will provide for early identification, evaluation, and treatment of signs and symptoms. It should address—

■ Injury and illness recordkeeping.
■ Early recognition and reporting.
■ Systematic evaluation and referral.
■ Conservative treatment.
■ Conservative return to work.
■ Systematic monitoring.
■ Adequate staffing and facilities.

Training and education

The purpose of training and education is to inform employees about the ergonomic hazards to which they may be exposed so they are able to actively participate in their own protection. At a minimum, provide training for—

■ All employees, with high-risk employees receiving prioritized training.
■ Process engineers and maintenance personnel.
■ Supervisors.
■ Managers.
■ Health care providers.

Training should cover—

■ The varieties of CTDs.
■ What risk factors cause or contribute to them.
■ How to recognize and report symptoms.
■ How to prevent CTDs.

In addition, new employees should receive an orientation and hands-on training prior to starting tasks with potential ergonomic stressors.

Ergonomic training information and technical assistance is available from both the U.S. Army Safety Center and the U.S. Army Environmental Hygiene Agency. Contact—

Training Division
U.S. Army Safety Center
Fort Rucker, AL 36362-5363
Telephone: DSN 558-4479 or commercial 205-255-4479
FAX: DSN 558-5318 or commercial 205-255-5318
Electronic Mail: dierberp@rucker-safety.army.mil

Special Services Branch
Industrial Hygiene Division
U.S. Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010-5422
Telephone: DSN 584-3928 or commercial 410-671-3928
FAX: DSN 584-3665 or commerical 410-671-3665
Electronic Mail: hshbmiw@aeha1.apgea.army.mil

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Checklists

General workstation design principles

The following general workstation design principles will—

■ Help in achieving an optimum match between work requirements and worker capabilities.

■ Maximize the performance of both the worker and the system while maintaining human comfort, well-being, efficiency, and safety.

1. Make the workstation adjustable to accommodate persons of varying heights and sizes.

2. Provide all materials and tools in front of the worker to reduce twisting motions.

3. Provide sufficient work space for the whole body to turn.

4. Avoid static loads and fixed work postures. Avoid job requirements where a worker must—

■ Constantly hold or grasp an object.

■ Lean to the front or the sides or support the body's weight with one leg.

■ Hold an extremity in a bent or extended position such as extending the upper arm greater than 30° from the body.

■ Tilt the head forward more than 15°.

■ Bend the torso forward or back more than 15°.

■ Perform sustained overhead reaches.

5. Set the work height at 2 inches (5 cm) below the elbow.

6. Provide adjustable, properly designed chairs with these features:

■ Adjustable seat height.

■ Adjustable armrest.

■ Adjustable backrest that includes a lumbar (lower back) support.

■ Padding that will not compress more than an inch under the weight of a seated individual.

■ Chair that is stable to the floor at all times.

In addition, a worksite evaluation may determine the need for a footrest.

7. Allow workers, at their discretion, to alternate between sitting and standing. Provide floormats or padded surfaces for prolonged standing.

8. Support the limbs. Provide elbow, wrist, arm, foot, and back rests where needed.

9. Use gravity to move materials when possible.

10. Design the workstation so arm movements are continuous and curved. Avoid straight-line, jerking arm movements.

11. Design so arm movements pivot about the elbow rather than the shoulder to avoid stress on the shoulder, neck, and upper back.

12. Keep arm movements in the normal work area to eliminate excessive reaches over 16.7 inches (40 cm).

13. Provide dials that are simple, logical, and easy to reach and operate.

14. Eliminate or minimize the effects of undesirable environmental conditions

such as noise, heat, humidity, cold, and poor illumination.

15. Encourage worker input/ involvement in workstation design.

Materials handling

A poorly designed materials-handling task is one where the strength requirements to complete the task exceed the strength capabilities of most workers. Simply put, most workers would not be able to perform the task without overexertion.

Poorly designed tasks generally require workers to lift, lower, push, pull, or carry heavy loads. These tasks may also include excessive bending, reaching, or twisting of the body.

A task is potentially hazardous if it includes one or, more significantly, a number of the following activities:

1. Lifting, lowering, or carrying more than 22 pounds (10 kg).
2. Lifting or lowering an item with one hand and/or rough, jerking motions rather than with a two-handed, smooth motion.
3. Lifting, lowering, or carrying bulky objects that cannot be held close to the body.
4. Repetitively handling/lifting materials more than 3 or 4 times per minute per 8-hour workshift.
5. Lifting or lowering between floor and waist height.
6. Lifting or lowering above shoulder height.
7. Lifting or lowering objects in cramped work areas that may result in twisting the torso (i.e., lifting and twisting in one motion).
8. Exerting forces in awkward positions—to the side, overhead, or at extended reaches.
9. Handling difficult-to-grasp items (no handles).
10. Handling items that place high pressure on the hands from thin edges, such as pail handles or sheet-metal edges.
11. Pushing or pulling carts, boxes, etc., that require large breakaway forces to get started.
12. Lifting and carrying items on walkways that are obstructed, poorly illuminated, slippery, too narrow, or congested with vehicle and/or pedestrian traffic.

Design of safe hand/wrist job activities

Use this checklist as a guide for designing safe hand and wrist activities.

1. Reduce the number of repetitions per shift. A job may be considered repetitive if there are more than 1,000 repetitions per 8-hour shift (that is, the cycle time to complete a task is less than 30 seconds).
2. Avoid systems where the pace is controlled by the machine and not the worker.

3. Maintain neutral (handshake) wrist positions. Design jobs and tools so that the wrist does not need to be flexed forward, extended backwards, or bent from side to side.

4. Reduce the force or pressure on the wrists and tools:

- Reduce the weight and size of objects that must be handled repetitively.
- Avoid tools that create pressure on the base of the palms, which can obstruct blood flow and nerve function.
- Avoid repetitive pounding with the base of the palm.
- Curve (pad) all work surface edges and contact surfaces.
- Avoid repeated forceful pressing with the fingertips such as tasks which require a pinch grip.

5. Design tasks so that a power grip rather than a finger pinch can be used to grasp materials. Note that a pinch grip is five times more stressful than a power grip.

6. Avoid reaching more than 15.7 inches (40 cm) in front of the body for materials. Avoid reaching above shoulder height, below waist level, or behind the body to minimize shoulder disorders. Also, avoid repetitive work that requires the elbow to be held straight and the arm extended.

7. Provide support devices where awkward body positions (elevated hands, elbows, and extended arms) must be maintained.

8. Avoid tools and equipment that transmit vibrations to the hands.

9. Avoid exposure of the hands to cold, hot, and humid environments.

10. Avoid wearing gloves whenever possible—gloves can increase grip strength requirements and reduce manual dexterity. If gloves are required, wear the right size.

11. Select and use properly designed handtools.

Proper design of carrying tasks

To eliminate the need to carry heavy objects—

- Rearrange the workplace to eliminate unnecessary movement of material.
- Use mechanical handling aids such as—
  - □ Conveyors
  - □ Lift trucks
  - □ Hand trucks
  - □ Tables or slides between workstations
  - □ Four-wheel carts or dollies
  - □ Air or gravity press ejection systems
  - □ Overhead cranes

To reduce the weight that is carried—

- Reduce the weight of the object.
- Reduce the weight of the container.
- Reduce the load in the container.
- Specify quantity per container to suppliers.
- Eliminate one-handed carries.
- Increase coefficient of friction between hand and container.

To reduce the bulk of materials that are carried—

- Reduce the size or shape of the object or container.
- Provide handles or handgrips that allow materials to be held close to the body.
- Assign the job to two or more persons.

To reduce the carry distance—

- Relocate receiving, storage, production, or shipping areas.
- Use powered and nonpowered conveyers.

To convert carry to push or pull—

- Use nonpowered conveyors.
- Use hand trucks and pushcarts.
- Push rather than pull when possible.

Proper design of pushing and pulling tasks

To eliminate the need to push or pull, use—

- Conveyors (powered and nonpowered).
- Powered trucks.
- Lift tables.
- Slides or chutes.

To reduce the force required to push or pull—

- Increase the coefficient of friction of the hand-handle interface.
- Reduce the size and/or weight of the load.
- Use four-wheel trucks or dollies.
- Use nonpowered conveyors.
- Require that wheels or casters on hand trucks and dollies have periodic lubrication of bearings, adequate maintenance, and proper sizing (provide larger diameter wheels and casters).
- Maintain floors to eliminate holes and bumps.
- Increase coefficient of friction of the shoe-surface interface.

To reduce the distance of the push or pull—

- Relocate receiving, storage, production, or shipping areas.
- Improve production process to eliminate unnecessary material handling steps.

To optimize the technique of the push or pull—

- Eliminate one-handed pushing or pulling tasks.
- Provide variable-height handles so that both short and tall persons can maintain an elbow bend of 80° to 100°.
- When pulling, make sure wrists are not fully pronated.
- Replace a pull with a push whenever possible.
- Use ramps with a slope of less than 10 percent.
- Keep exertion within shoulder to mid-thigh (standing) vertical range.

Proper design of lifting and lowering tasks

To optimize material flow through the workplace—

- Reduce manual handling of materials to a minimum.
- Establish adequate receiving, storage, and shipping facilities.
- Maintain adequate aisle and access areas.

To eliminate the need to lift or lower manually, use—

- Lift tables and platforms.
- Lift trucks.
- Cranes and hoists.
- Drum and barrel dumpers.
- Elevating conveyors.
- Elevated pallets.
- Gravity dump systems.
- Gravity chute systems.
- Vacuum systems.
- Automatic feed systems.

To increase weight to a point where it must be mechanically handled—

- Palletize handling of raw materials and products.
- Use the unit load concept (bulk handling in large bins or containers).

To reduce the weight of the object—

- Reduce the weight and capacity of the container.
- Increase the coefficient of friction between the hand and the container.
- Reduce the load in the container.
- Specify the quantity per container to suppliers.
- Assign the job to two or more persons.

To reduce the hand distance from the body—

- Change the shape of the object or container.
- Provide grips or handles.
- Provide better access to objects.

To convert lift/carry or lower/carry combinations to a push or pull, use—

- Conveyors.
- Hand trucks.
- Ball-caster tables.
- Four-wheel carts.

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